

IV. *On the Anatomy and Systematic Position of a Gigantic Earthworm (Microchaeta rappi) from the Cape Colony.* By FRANK E. BEDDARD, M.A., F.R.S.E., F.Z.S., *Prosecutor to the Society.*

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[PLATES XIV., XV.]

INTRODUCTORY REMARKS.

SOME forty years ago there was published in the 'Transactions' of the Würtemberg Academy of Sciences<sup>1</sup> a brief account, accompanied by a plate, of a gigantic Earthworm, a native of the Cape of Good Hope. The author of this paper, Dr. Rapp, contented himself with describing the more obvious external and internal characters, and his description will be considered in reference to the several points with which it deals in the course of the present Memoir. Unfortunately at the time when Rapp published his account of "*Lumbricus microchaeta*," as he termed this Earthworm, the recorded observations on the anatomy of the group were extremely few, and in consequence it was impossible to compare its structure with other forms. It is not surprising, therefore, to find many structural details, which are now known to be extremely important for classificatory purposes, omitted, and others too briefly described to be of much use, in Rapp's paper; it would, in fact, be quite impossible to decide upon the accurate systematic position of *Lumbricus microchaeta* from its perusal, although M. Perrier<sup>2</sup> is quite right in stating that it cannot at any rate belong to the genus *Lumbricus* as now understood.

Of late years more attention has been directed to this very interesting group of animals, and we are now in possession of a very rational scheme of classification, which is due to M. Perrier<sup>3</sup>. This classification is based upon internal structure, though taking in consideration also certain external characters; the impossibility of deciding upon the zoological rank and affinities of an animal by external characters alone is perhaps more strikingly emphasized in the Oligochaeta than in any other group in the whole animal kingdom; indeed it appears quite obvious that it should be so when we consider that the differences of habit, physiological needs, and so forth cannot be great between different species.

Setting aside the previous systems of classification, which mainly depended upon the

<sup>1</sup> Jahresheft. d. Ver. f. vaterl. Naturk. in Würtemberg, Jahrg. iv. (1848) p. 142.

<sup>2</sup> Arch. de Zool. Exp. t. ix. p. 239, note. At the conclusion of his paper Rapp does suggest the formation of a new genus *Microchaeta*, which I adopt here, naming the species after Rapp, since he first described it.

<sup>3</sup> Nouvelles Arch. d. Museum, t. viii.

arrangement of the setæ, M. Perrier directed attention to the variability of the generative system, and divided the *Oligochæta terricola* into three main groups:—(1) *Lombriciens preclitelliens*, (2) *Lombriciens intracitelliens*, and (3) *Lombriciens post-clitelliens*; in the first of these the ducts of the testes open in front of the clitellum, in the second group they open within it, in the third they open behind. The number and position of the copulatory pouches, the characters of the vascular system, and so forth, serve to subdivide these three orders into genera and into species; even the species are found to differ by definite internal characters, generally the number and structure of the copulatory pouches.

Being anxious to secure a specimen of *Lumbricus microchæta*, I wrote to the Rev. G. R. Fisk, C.M.Z.S., of Breakwater, Cape Town, who most kindly secured and sent to me a fine living specimen of the worm, which arrived in perfect safety at the end of August last. Mr. Fisk had previously brought the matter before the Philosophical Society of Cape Town<sup>1</sup> in order to obtain information as to the way in which a specimen could be got. In the discussion which followed, a number of interesting facts respecting the occurrence of these gigantic creatures were made known, which are well worth repeating here; I quote the following passages:—“Professor Guthrie could vouch for Earthworms of 4 feet in length, though he believed they only appeared after very heavy rains. He remembered going down to Port Elizabeth in 1876, and when near Jansenville he was surprised to see a number of these monstrous worms creeping about on the ground, which was then very wet. These worms were quite 4 feet long, and on lifting one of them on his stick both ends hung to the ground; that must have been nearly 6 feet, though of course when lifted on the stick it was stretched out.

“Mr. Bolus said that he had seen a similar thing in 1874 . . . immediately after excessively heavy rains. The whole of the road for some distance was thinly covered with these worms, there being some hundred or two of them. These worms were about as thick as one’s fore finger, and about 5 feet in length. The soil was Karroo soil, and was usually extremely dry. The colour of the worms was somewhat lighter than the ordinary Earthworms, and was of an ash-grey tint. Mr. Trimen, in Natal, had seen large Earthworms of from 2 to 3 feet in length after heavy rains. They were of a green tint, and presented a most unpleasant appearance.”

Another piece of information respecting these worms is contained in a letter kindly addressed to me from a gentleman resident in Kleinpoort; of the occurrence of these creatures Mr. de Witt Meulen says, “These worms appear only one, two, or three times a year . . . when the ground has been thoroughly soaked by an abundant downpour of rain. . . . They never seem to return into the earth, but to be killed within six hours by the heat of the sun. . . . The ground here is very hard, chiefly clay, and when any water is found under it it is invariably brackish. I may add that no domestic animal whatever—dogs, pigs, fowls, &c.—touch them.”

<sup>1</sup> Reported in ‘The Cape Times’ for Thursday, May 29th, 1884; see also ‘Nature,’ Oct. 9th, 1884, p. 570.

The fact that these animals will live in soil impregnated with brackish water is highly interesting; we know of two other species, however, which live among decaying vegetable matter cast up by the sea, and therefore quite salt—these are *Pontodrilus littoralis* and *Pontodrilus marionis*<sup>1</sup>. Such facts may possibly help to get over the great difficulties connected with the geographical distribution of these animals. It was formerly believed that Earthworms and their eggs were killed by immersion in salt water, and it was presumed, therefore, that the facts in their geographical distribution would be of particular value, inasmuch as the species would be indigenous to the countries where they were found<sup>2</sup>, and the presence, in two countries separated by the sea, of the same, or at least closely allied genera, would furnish very strong evidence in favour of a land connection having existed formerly between the two regions. Since we find closely allied species, let alone genera, in widely separated countries<sup>3</sup>, the occurrence of which is hardly explicable by the interference of man, the facts stated above seem to suggest that the cocoons of Earthworms may, after all, be transported across the sea on floating timber.

#### *External Characters.*

The extreme length of *Microchæta rappi* it is difficult to state with certainty; during its lifetime the animal elongates and contracts itself so very much; the accompanying drawing (Pl. XIV.) represents very fairly the average length of the animal, which appears to be between 4 and 5 feet. When killed and placed in spirit it contracted itself to 38 inches. The colour when living is admirably illustrated by Mr. Smit's drawing, which was made from the living animal.

The dorsal surface is dark green, the colour being especially bright for a space of about 3 inches near the anterior end of the body, elsewhere it passes into a duller greenish violet; the ventral surface is of a flesh-red; when placed in spirit the colour after a time faded to a dull grey, but the bright green patch in front, corresponding in fact to the clitellum, remained for a very long time.

The setæ are arranged in two pairs as in the common British *Lumbricus terrestris*, and nearly equidistant from each other. As pointed out by Rapp they are extremely small and inconspicuous, and tend to disappear altogether at the anterior end of the body; this makes it extremely difficult to fix accurately the boundaries of the segments in this region, since, as will be pointed out presently, the mesenteries have lost their

<sup>1</sup> Perrier, Arch. d. Zool. Exp. t. ix.

<sup>2</sup> Except, of course, such anomalies as were evidently caused by the agency of man, e. g. the occurrence of *Perichæta* in hothouses in England and the Jardin des Plantes at Paris; these specimens have, no doubt, been imported along with plants from foreign countries.

<sup>3</sup> As an instance of this, the distribution of *Acanthodrilus* may be adduced; there are seven species of the genus known—three from Africa, one from Madagascar, two from New Caledonia, and one from Kerguelen Island, and another, which I hope to describe shortly, came in the same box with the large Earthworm described in the present paper. I have also received examples of three distinct species from New Zealand.

distinctive character, and are metamorphosed into a mass of fibres uniting the pharynx to the parietes, while the external segmentation is not distinct, since most of the segments are, as in other Earthworms, divided again by additional transverse furrows.

In front of the upper row of setæ are a pair of apertures on either side of the body; these are the openings of the segmental tubes; the position of these apertures is the same as that found in *Urochæta*, *Anteus*, *Rhinodrilus*, *Eudrilus*, and *Moniligaster*; in *Lumbricus* and other genera the segmental tubes open in front of the ventral pair of setæ.

When the animal was placed in spirit the orifices of the segmental tubes were rendered very conspicuous by the expulsion through them of a quantity of fluid which settled down as a flocculent precipitate.

The most careful search failed to show any dorsal pores; as, however, these structures are occasionally absent in Earthworms (*e. g.* in *Pontodrilus*), the fact is not remarkable.

The specimen appeared to be fully mature, and the clitellum occupies about twenty segments, from segment ten to thirty inclusive; it is however only developed upon the dorsal surface, and is distinguishable in the living animal, and, to a less degree, after prolonged immersion in spirit, by a light-green colour well shown in Pl. XIV.; on the ventral surface of the body, in the region of the clitellum, the green colour is replaced by a flesh-red, which faded to a yellowish grey under the action of alcohol.

The male generative ducts open on to the eighteenth segment, but I was unable to detect their apertures on the outside of the body; the termination of each vas deferens was, however, plainly visible from the inside.

The position of the apertures is therefore within the clitellum, and *Microchæta* clearly belongs to the intraclitellian group of Perrier.

There are a number of papillæ developed in certain of the anterior segments of the body, which no doubt serve to attach the animals together during copulation; they correspond in every case to the innermost pair of setæ. The presence of such papillæ is very common in Earthworms, and they are frequently provided with special glands. In *Microchæta* the glands of the papillæ are arranged three to each papilla; they are somewhat oval in shape, and conspicuous from their whitish colour; the three glands are in contact with each other, and radiate outwards from the point of opening on to the papilla. These glands are often termed capsulogenous glands, as they are believed to assist in the secretion of the cocoon.

#### *Nephridia.*

The nephridia of this worm are very remarkable. Their orifice in front of the upper pair of setæ (*cf.* Pl. XIV.) is noticed and figured by Rapp, who gives the following description of the organs themselves (*loc. cit.* p. 143):— . . . “Runde Oeffnungen, die

in ein kleines, unter der Haut liegendes Bläschen führen, es scheinen Schleimabsonderungswerkzeuge (oder Respirationsorgane!) zu sein." From this description it is clear that Rapp did recognize the peculiar form of these organs in *Microchata*. On opening the body of the animal immediately after it had been killed by immersion in weak spirit a number of long oval sacs, distended by their fluid contents, were apparent in several of the anterior segments of the body, a pair to each segment; it appeared at first that these might be the copulatory pouches, since the rest of the organs—which lies almost under the alimentary canal, and close to the mesenteries, which are here specially thickened and muscular—was invisible; on further dissection, however, these vesicular structures turned out to be diverticula of the duct of the nephridium.

Several of these are displayed in Pl. XV. fig. 6; each consists of (1) a tuft of coiled glandular tubes communicating with (2) a wide, but thin-walled duct which narrows abruptly into a short, thick tube, distinguished from the rest of the duct by its yellow colour; this latter opens on to the exterior by a pore situated just behind the more dorsally placed pair of setæ. The duct of the nephridium, near the external opening, gives off posteriorly a long, oval, cæcal tube; this is supported by a delicate membrane which runs along the whole of its posterior surface, and is attached to the body-wall.

The nephridia of the anterior part of the body, down to about the twenty-seventh ring, have the same structure that has been described; there are a pair to each segment as far forward as that which immediately follows the pharynx, which is bounded in front by the most anterior of the specially thickened mesenteries. In front of this mesentery there are only two pairs of nephridia, which are imbedded among the confused mass of muscular fibres representing the most anterior mesenteries. I am not able to state how many segments are included in this region of the body, unless the setæ really mark the number of segments, in which case there are three.

The internal opening of the segmental tubes, however, is not within the same segment that contains the greater part of the organ, and on to the outer wall of which it opens; it was quite easy to make out that the proximal portion of the tube perforated the mesentery forming the anterior boundary of the segment, and terminated freely within the cavity of the segment in front in a ciliated funnel (Pl. XV. fig. 6); about  $\frac{1}{10}$  of an inch, or rather less, of the proximal clear-walled portion of the tube depended freely within this segment. A similar arrangement is usual among Earthworms. In the hinder part of the body, from segment twenty-eight onwards, the form of the segmental organs is a little different. The glandular portion consists, as in the more anterior series, of a tuft of tubules generally disposed in loops, the tubes forming the loop being variously coiled round each other. This part of the organ is situated close to the ventral blood-vessel, and is partly covered by the alimentary canal, as in the more anteriorly placed nephridia; it appears, however, to be proportionally smaller. The duct forms a wide, thin-walled tube, and opens by a thick, short, terminal portion; the duct is, however, prolonged beyond its aperture and towards the dorsal

surface in the way shown in fig. 3, Pl. XV. The portion of the duct which lies beyond (above) the aperture evidently corresponds to the vesicular diverticulum of the more anterior nephridia.

The large size of the nephridia ( $\frac{3}{4}$  inch) rendered it quite easy to inflate the duct by means of a blow-tube, and to make sure of the connection between the duct and the diverticulum, though this was sufficiently obvious without.

The upper portion of the wide muscular duct of the segmental tubes in this region of the body is thickly covered by a layer of large cells filled with round, clear bodies of a brownish tint; these were so numerous as to obscure the nucleus altogether. The presence of these cells gives a yellowish colour to that part of the nephridium where they exist, the rest being almost colourless. These cells appear to be simply modified cells of the perivisceral cavity; they are also extremely abundant on the intestine, where their occurrence has been long known in the common Earthworm. It is very remarkable to find them only covering the nephridia of the posterior half of the body, and absent from the more anterior series in *Microchæta*. In fig. 3, Pl. XV., are displayed some of the nephridia of the posterior region of the body; the distribution of the "chloragogenic" cells is indicated by the dotting on the terminal section of the nephridium; below this region, which ends very abruptly, are hardly any traces of these cells, only a few being visible here and there. The statement that these peculiarly modified perivisceral cells are absent also from the anterior series of nephridia does not of course imply that these latter have no peritoneal covering.

The nephridia of *Microchæta* are, on the whole, similar to those of other Earthworms, but differ by the disproportionate development of the terminal muscular portion of the organ, and also by its large diverticulum. A similar diverticulum is figured by Gegenbaur in *Scœnuris*<sup>1</sup>.

In certain of the anterior segments of the body there are a number of structures developed near the orifice of the segmental organs which have some interest in connection with the much debated question of the homologies between the nephridia and the copulatory pouches.

These are represented on fig. 4 of Pl. XV., and more highly magnified in fig. 6. In the thirteenth segment is a single minute whitish body about the side of a millet-seed; this body is a cæcal pouch with muscular walls opening on to the exterior of the body in front of the nephridium. In the succeeding segment there are four of these pouches arranged as in the figure, the two innermost being partly fused; in segment fifteen the disposition of these pouches is entirely similar, except that the two innermost are connected together at their upper instead of at their lower extremities; finally, in segment sixteen there is only a single pair of these pouches corresponding to the innermost pair of the two segments immediately antecedent.

<sup>1</sup> "Ueber die sogenannten Respirationsorgane der Regenwürmer," Zeitschr. f. wiss. Zool. Bd. 1852.

On the opposite side of the body an exactly equivalent series of pouches is present. I have ascertained by transverse sections that these structures are, as is stated, cæcal pouches opening on to the exterior of the body.

A second individual of this Earthworm, which was acquired by Mr. Bartlett, and lived for a short time in the Society's Gardens, showed some slight variation in the number of these pouches. On the left-hand side of the body the first segment has two, the second four, one being in reality double, the third and fourth segments three each. On the right-hand side of the body the first segment had two of these pouches, the two next three, and the last two. These variations are not, however, of any importance, I should imagine.

These structures are not peculiar to *Microchæta*, but are represented in a species of *Perichæta*. In *Perichæta aspergillum* M. Perrier<sup>1</sup> figures a series of small accessory bodies developed in the neighbourhood of the copulatory pouches, and I have reproduced in fig. 7 of Pl. XV. M. Perrier's drawing in order to display the close resemblance between the two sets of structures; there can be little doubt that they correspond to each other, and their development in connection with the copulatory pouches in one worm and the segmental organs in the other is, at least, an indication of an homology between these latter, an homology which is undoubtedly supported by other facts. In any case the very close similarity between the copulatory pouch of *Perichæta* (fig. 7) with its accessory pouches, and the segmental organ of *Microchæta* (fig. 6) with a corresponding series of accessory pouches, is worth remarking as a curious coincidence, if no more.

It must also be remembered that true copulatory pouches like those of other Earthworms are absent in *Microchæta*, though their function is probably taken on by the structures already described; and it is not at all likely that the copulatory pouches, were they present, would have escaped attention in two separate individuals, since they are so extremely conspicuous in other Earthworms, even in immature individuals. It is possible that the correspondence between the copulatory pouches and the nephridia of Earthworms is only partial, that is to say, that the nephridia and the copulatory pouches are both derivable from a segmental organ like that of *Microchæta* with a large diverticulum. This hypothesis would explain several of the difficulties which beset the question of the homologies between the two structures; it might for instance account for the presence of a segmental organ and a copulatory pouch opening close together upon the same series of setæ in *Urochæta*. Furthermore it is possible that the small diverticulum of the copulatory pouches found in so many species of *Perichæta* (see fig. 7, Pl. XV.) is a rudiment of a nephridium opening in common with it as in

<sup>1</sup> For a discussion of the homologies between the segmental and the ducts of the generative system, including the copulatory pouches, see Lankester, Quart. Journ. Micr. Soc. 1864; Perrier, Arch. d. Museum, 1872, and other memoirs already cited.

*Microchata*; in *Urochata* and other Earthworms<sup>1</sup> where the nephridium opens upon the same series of setæ as the copulatory pouch, the latter has no such rudiment, which is exactly what would be expected on this hypothesis.

Another fact, which is of some importance from this point of view, is the condition of the spermathecæ in *Ocnerodrilus*<sup>2</sup> as diverticula of the vas deferens.

I am of course quite aware that this is very hypothetical, and I merely make the suggestion for what it is worth.

In any case it is interesting to notice that the structures which no doubt function as spermathecæ are placed behind the testes; it is invariably the case in other Earthworms that the spermathecæ lie anterior to, or at most in the same segments with, the testes.

### *Circulatory System.*

The circulatory system of *Microchata* presents some peculiarities which, so far as I am aware, have not been recorded in any other Earthworm except *Megascolex cæruleus*<sup>3</sup>. The dorsal vessel, instead of being a simple tube, is composed of two distinct tubes only fused here and there; on Pl. XV. fig. 2, is a drawing of other dorsal and ventral vessels, together with the connecting hearts, slightly diagrammatic. The dorsal vessel, in segment three, is a simple tube; in the succeeding segment it is double, but the two halves are closely bound together, and only recognizable as distinct by the presence of two quite separated blood-clots lying side by side in the apparently single tube; at the hinder margin of the segment a pair of transverse vessels unite the dorsal with the ventral blood-vessel; in segment five the dorsal vessel divides immediately after passing through the mesentery into two separate tubes, which unite at the posterior end of the segment into a much dilated receptacle; with this are connected the two pairs of hearts of the segment; in the following segment, that which contains the gizzard, the dorsal vessel again splits into two halves, which are widely divaricated, but meet and fuse together before giving off the pair of hearts; the arrangement of the vessel in segment seven is precisely similar. In the next segment the dorsal vessel is apparently simple, and forms a very wide chamber, at least double the width of the same vessel in the preceding or succeeding segments; on slitting it open, however, it was found to be divided by a longitudinal septum reaching nearly as far as the posterior extremity; at this point the septum disappears, and the cavity is single; the exit of the two "hearts" is guarded by a valve on either side. In the two succeeding segments the dorsal vessel

<sup>1</sup> *Eudrilus* appears to form an exception to this rule; but the structures described by Perrier as copulatory pouches are altogether so anomalous, that their correspondence with the copulatory pouches of other Earthworms cannot be regarded as certain, as Perrier himself implies.

<sup>2</sup> Eisen, *Nova Acta Soc. Reg. Sci. Upsala*, vol. x.

<sup>3</sup> F. E. Beddard, "On the Anatomy and Histology of *Pleurochata*," *Trans. Roy. Soc. Edin.* vol. xxx. p. 481. This genus is really identical with Templeton's *Megascolex*. At the time when I wrote I had not seen the type-specimens and Templeton's description is too vague to be of any use in recognizing the worm.



is single, and gives off on either side a pair of large "hearts," uniting it with the ventral vessel.

The existence of a double dorsal vessel appears to be an embryonic character, inasmuch as the single dorsal vessel of *Lumbricus* and of *Criodrilus* is formed by the coalescence of two vessels, at first distinct<sup>1</sup>.

#### *Alimentary System.*

The alimentary canal commences by a large pharynx occupying the anterior three or four segments of the body, which is firmly attached to the body-wall by innumerable muscular bands; the œsophagus is long and narrow, and, as in most other intra- and postclitellian Earthworms, is continued beyond the gizzard; in *Lumbricus* the gizzard marks the posterior boundary of the œsophagus. Two or three segments behind the gizzard is a peculiar dilatation of the œsophagus (see fig. 4*f*, Pl. XV.), conspicuous by its reddish-purple colour, which is caused by the presence of a rich network of blood-vessels almost entirely covering its surface; on slitting open this section of the œsophagus it was found to have the appearance represented in fig. 5 of Pl. XV.; the epithelium is extremely thin and transparent, and covers an extraordinarily developed plexus of blood-vessels, composed of larger trunks running from end to end, and connected here and there by small transverse branches; no trace of the vascular network could be detected in the rest of the œsophagus—the network disappeared entirely at the junction of this dilatation with both the preceding and succeeding sections of the œsophagus. The existence of a vascular plexus, or rather sinus, within the coats of the alimentary canal has been recorded by Vejdovsky in the Limicolous family Enchytræidæ; in these worms the dorsal vessel, instead of running continuously from one end of the body to the other, ceases to be visible at the commencement of the intestines, and in fact enters the tissues of the organ at this point and forms a continuous sinus entirely surrounding the gut, but lying between its two muscular coats. In the same memoir Dr. Vejdovsky describes two cæcal diverticula from the commencement of the mid gut, exactly at its junction with the œsophagus, which are similarly furnished with a network of vessels within their substance; these are compared to a dilatation occurring at the hinder end of the œsophagus in *Enchytræus ventriculosus*<sup>2</sup>, which appears to be very closely similar to the structure I have just described in *Microchæta*; the walls are specially thickened and contain an immense number of clear vessels, which Dr. Vejdovsky presumes, from analogy, to be blood-vessels; he does not particularly describe the minute structure of this vascular dilatation, merely remarking its probable homology with the paired diverticula of other species of *Enchytræus*; Dr. Vejdovsky furthermore suggests that this organ functions as a liver, and corresponds morphologically with the paired cæca so commonly found in the genus *Perichæta*.

<sup>1</sup> Balfour, 'Comparative Embryology,' vol. i. p. 282.

<sup>2</sup> 'Monographie der Enchytraeiden,' Prag, 1879, loc. cit. pl. vi. fig. 4, *ldr.*, pp. 33–35.

If this last comparison be just, it is of course impossible to compare the dilation of the œsophagus in *Enchytræus ventriculosus* with that in *Microchæta*, which is clearly a portion of the œsophagus, and has nothing to do with the mid gut; on the other hand it seems to me also possible that the vascular dilatation of the œsophagus in *Enchytræus ventriculosus* may in reality correspond more closely with a somewhat similar structure in *Ocnerodrilus*. In this Annelid Eisen<sup>1</sup> has described a pair of cæca developed from the œsophagus at a considerable distance from the mid gut; he does not, however, make any statements regarding their structure. It seems to me that the œsophageal dilatation of *Microchæta*, as well as these structures just referred to, probably correspond to the calciferous glands of *Lumbricus*.

The remainder of the alimentary canal in *Microchæta* presents no features of special interest.

The intestine is capacious and furnished with a typhlosole which disappears at the hinder end of the body. The typhlosole presents a spongy appearance when examined with a lens, which is due to the immense development of blood-capillaries of various dimensions, which almost entirely fill up its interior; the interstices between the capillaries are occupied by large brown cells, evidently similar to those which clothe the outer surface of the intestine, the blood-vessels, and the segmental organs in the last half of the body. The intestine is unprovided with cæca or with glands of any description, as is remarked by Rapp.

#### *Generative System.*

(1) The *clitellum* occupies an unusually large number of segments; it extends from about segment ten to thirty, occupying therefore some twenty segments; it is distinguishable from the rest of the integument by its colour, which is of a bright green: this is well shown in the accompanying Plate (Pl. XIV.); the colour faded to a considerable extent in alcohol, but at the time of writing this (some three months after the worm was placed in spirit) it is still recognizable; the clitellum does not, however, extend very far ventrally; the peculiar green colour ceases at the apertures of the segmental organs and is replaced by a flesh-red. Perrier notices the same disposition of the clitellum in *Anteus*; in that worm, as in *Microchæta*, the clitellum is not developed on the ventral surface of the body. The structure of the clitellum apparently differs from that of *Lumbricus*; the latter has been investigated by Claparède, and more recently by Dr. Horst and Dr. v. Mojsisovics; the statements of the two last-named writers are in harmony with each other, but both differ considerably from the account given by Claparède. According to Claparède the hypoderm layer of the general body-surface is continued over the clitellum, but in that region of the body a glandular layer is interposed between the hypoderm and the layer of transverse muscles; the glandular layer

<sup>1</sup> G. Eisen, "On the Anatomy of *Ocnerodrilus*," *Nova Acta Soc. Reg. Sci. Upsala*, vol. x. (series 3).

consists of two rows of cells termed respectively the "untere" and "obere Säulenregion;" below this, again, is a vascular layer.

Drs. Horst and v. Mojsisovics interpret the structure of the clitellum differently. According to them the hypoderm layer becomes modified in the region of the clitellum; its cells are considerably longer than elsewhere, and have taken on a glandular character; below these is another layer of cells, which are distinguishable from the upper layer by their larger size, shape, and less granular contents; the upper row of cells corresponds therefore to the hypoderm *plus* the "obere Säulenregion" of Claparède, while the lower layer corresponds to the "untere Säulenregion."

The figures of transverse section of the clitellum given in Dr. von Mojsisovics's paper are not really so very different from those of Claparède, and it is, indeed, difficult to understand why the latter should have insisted upon the distinctness of the hypoderm layer from the "obere Säulenregion," inasmuch as he *figures* the cells of the two regions in some cases in actual contact, and, indeed, hardly indicates a septum of division at any point. It is a curious fact that the ultimate branches of the blood-system only reach halfway up to the outer layer of cells, and terminate precisely where, on Claparède's hypothesis, is the line of division between the hypoderm and "obere Säulenregion," and it is very possible that this fact caused Claparède to distinguish them.

A transverse section through the body-wall of *Microcheta*, in the region of the clitellum, is represented in fig. 8 of Pl. XV. The epidermis of the general body-surface is here unmodified; it is quite impossible to distinguish the cells which form the epidermis of the clitellum from those which are found elsewhere; the same narrow columnar cells, each with an oval nucleus situated near the lower end of the cell, form the chief part of the tissue, while here and there a larger granular cell occurs. The resemblance is in fact so complete that I have not thought it worth while to reproduce the epidermis of the general body-surface in another figure.

The epidermis layer (*e*) is of course covered by the chitinous cuticle (*c*), and is bounded below by a stout membrane, which sends off prolongations both from its upper and lower surface; the former pass upwards between the epidermis-cells and are no doubt similar to the "processes of pigment-cells belonging to the connective-tissue system" which make their way among the epidermis-cells of *Lumbricus* as described by the above-mentioned writers, as also by Prof. Lankester<sup>1</sup> (in the Leech). Beneath the epidermis is the glandular layer of the clitellum (*gl*); the glandular cells of this are imbedded in a network of connective tissue continuous with the membranes which separate the glandular from the hypodermic layer. The structure and arrangement of these glandular cells, again, appear to be different from that characteristic of *Lumbricus*.

In the latter the cells are arranged in a regular fashion in double rows, separated by septa of connective tissue. In *Microcheta* the glandular layer of the clitellum is

<sup>1</sup> "On Intra-epithelial Capillaries in the Integument of the Medicinal Leech," Quart. Journ. Micr. Soc. vol. xx. new ser. p. 303.

rather different; there is no such regularity in its arrangement, and the cells are aggregated into variously sized groups; this appearance is displayed in fig. 8 of Pl. XV. Whether these aggregations of cells are really independent glands or not I am unable to state; it is sufficiently evident, however, that the clitellum of *Microchaeta* does differ from that of *Lumbricus*, and I hope to be able to study it more fully at some future time. The description here is of preparations which have been only hardened in strong alcohol; this reagent appears to preserve the structure of the hypodermic cells very well indeed, but as I have not been able to compare its effects on the glandular region of the clitellum with that of other reagents, I am rather afraid of going into any more detailed description of the clitellum, and possibly describing the effects of the reagent instead of the real structure of the cells.

The glandular portion of the clitellum is extremely vascular, and sends off here and there a loop of capillaries which penetrate the hypoderm as in other Earthworms.

(2) The *testes*<sup>1</sup> (Pl. XV. fig. 14, *t*) are two pairs of oval somewhat flattened glands, situated in segments ten and eleven; the anterior pair are rather larger than the posterior; both are enveloped in a membranous sac, and are also firmly attached to the proximal portion of the vas deferens. The testes harbour an immense number of Gregarines. These parasites are constantly found in Earthworms.

(3) The *vasa deferentia* (Pl. XV. fig. 4, *vd*) are two delicate tubes, slightly sinuous, which open into the exterior of the body in the eighteenth segment just to the inside of the opening of the segmental tubes; at its point of aperture the vas deferens of either side is slightly dilated, but there were no traces of any prostate glands such as are so generally met with in Earthworms, especially in the postclitellian and intraclitellian genera. The position of these orifices *within* the clitellum shows that *Microchaeta* must be referred to the *Lombriciens intraclitelliens* of Perrier. The vasa deferentia are rather hard to follow; their diameter is almost exactly the same as that of the longitudinal muscle-bundles, and moreover in segment sixteen they appear to run within the latter; at any rate I was unable to see them in this segment, though they were, comparatively speaking, obvious in the preceding and the succeeding segment. In the twelfth segment the vas deferens bends inwards towards the middle line of the body and approaches its fellow of the opposite side; it perforates the mesentery and blends with a long, somewhat oval, solid-looking body lying beneath the testes of its own side, and almost in contact with the corresponding structure of the other side of the body. This structure represents the ciliated funnel of the vas deferens, which is, in this Earthworm, extremely complicated; instead of opening freely into the body-cavity its aperture appeared to be plugged by the testes, to which it was firmly attached by its posterior extremity; a transverse section showed that this structure does really represent the fimbriated aperture of the vas deferens. It contains numerous cavities lined by tall, columnar, ciliated cells, and its compact structure is due to an excessive complication of the folds

<sup>1</sup> Probably the equivalents of the seminal vesicles of *Lumbricus* and not the true testes.

into which the terminal portion of the vas deferens has been thrown; in the segment in front, which contains the anterior pair of testes, there is a similar body, which is attached to the testes of its own side, and also continuous with the terminal portion of the vas deferens lying in segment eleven; the ventral blood-vessel, which elsewhere lies upon the nerve-cord, comes to be some way removed from it in these two segments, in order to make room for the dilated extremities of the vasa deferentia which partly cover the nerve-cord. These structures and their relations to each other are exhibited in fig. 4 of Pl. XV. The arrangement of the terminal apertures of the vasa deferentia, their continuity with the testes, is evidently very favourable for conveying the seminal fluid to the exterior; in many Earthworms the fimbriated openings have no such direct connection with the testes, but lie on the posterior wall, while the testes themselves are attached to the anterior wall of the segment which contains them; in most cases, indeed, the apertures of the vasa deferentia are still further removed from the testes. In *Pontodrilus* the anterior pair of apertures are actually not in the same segment with the testes corresponding to them, but in the one in front.

(4) The *ovaries* (Pl. XV. fig. 4, *o*) are two small bodies attached to the mesentery which forms the anterior wall of segment thirteen; they are supplied with abundant blood-capillaries, which are frequently dilated in their course. Many observers have noticed a similar condition of the blood-capillaries in Earthworms, especially in those supplying the segmental organs; these dilations were visible with a hand-lens as reddish specks in the ovary, and, indeed, enabled me first to find the organ, which is sufficiently small—hardly, indeed, larger than in many small Earthworms.

(5) The position of the *oviduct* (Pl. XV. fig. 4, *od*), with reference to the ovary, is rather anomalous; the terminal aperture, which is very much folded, lies on the anterior side of the same mesentery which bears the ovaries, and consequently in segment twelve; it appears, however, that a portion of the terminal funnel, connected with the rest through the mesentery, opens into the same segment (segment twelve) that contains the ovary, and is bound to it by a membranous sheet; the two oviducts appear to open separately on to the exterior in the immediate neighbourhood of the inner pair of setæ.

(6) *Copulatory Pouches*.—There is no doubt that the small oval sacs (Pl. XV. figs. 4, 6, *c.p.*), already described in connection with the segmental organs, represent functionally the copulatory pouches of other Earthworms; but it is rather surprising to find that copulatory pouches of the ordinary size, and arranged in pairs, are absent. Perrier remarks upon the absence of copulatory pouches in another Intraclitellian genus *Titanus*. I have already pointed out that the series of small pouches in segments 13–16 correspond in all probability to quite similar structures in *Perichæta aspergillum*.

In conclusion I may briefly abstract from the foregoing description the generic definition of *Microchæta*.

## MICROCHÆTA, gen. nov.

*Lumbricus*, Rapp, Jahresb. d. Ver. f. vaterl. Naturh. in Württemberg, Jahr iv. (1848) p. 142.

Setæ arranged in pairs in four series; clitellum occupying about twenty segments (from segment ten to thirty), only developed in the dorsal region. Nephridia opening in front of the dorsal pair of setæ, present in all the segments of the body with the exception of one or two of the most anterior; testes two pairs in segments ten and eleven; vasa deferentia opening on to eighteenth segment, not furnished with a prostate gland or "penis;" ovaries on anterior wall of segment thirteen. Alimentary canal without cæca or special glands.

Copulatory pouches represented by a variable number of small pouches (one to four in each segment) in segments twelve to fifteen, opening on to the exterior in a line with the nephridia and close to them.

## EXPLANATION OF THE PLATES.

## PLATE XIV.

*Microchæta rappi*, drawn by Mr. Smit from the living worm. Natural size.

## PLATE XV.

*c*, cuticle; *e*, epidermis; *gl*, glandular layer of clitellum; *d*, dorsal vessel; *n*, nephridia; *c.p*, copulatory pouches; *m, m'*, muscular layers of body-wall; *t*, "testes;" *g*, gizzard; *f*, dilated vascular region of œsophagus; *o*, ovary; *ov*, oviduct; *v*, ventral blood-vessel; *h*, "heart;" *v.d*, vas deferens; *v.d.f*, funnel of vas deferens; *p*, mesenteries.

Fig. 1. Dissection of *Microchæta*, to show specially thickened mesenteries of anterior region.

Fig. 2. Main trunk of vascular system in anterior region of body.

Fig. 3. Four segments in posterior region of body, to show the position and form of the nephridia.

Fig. 4. Dissection of the genital region, to show genital glands and their ducts.

Fig. 5. Vascular dilatation of œsophagus cut open by longitudinal incision.

Fig. 6. Four segments of the body which contain the copulatory pouches.

Fig. 7. Diagram of copulatory pouch &c. of *Perichæta aspergillum*, copied from Perrier (Nouvelles Arch. d. Muséum, t. viii. pl. iv. fig. 72).

Fig. 8. Vertical section through clitellum to illustrate its minute structure.

Fig. 9. Muscle-fibres of transverse coat, very highly magnified.